D&D of Mercury Contaminated Drain Lines

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BACKGROUND

Battelle Memorial Institute (BMI) entered into Contract No. W-7405-ENG-92 with the Manhattan Engineering District on April 16, 1943, to perform atomic energy research and development (R&D) activities. Initial activities were performed at the Battelle Columbus Operations (BCO) King Avenue locations. Future expansion in atomic energy R&D activities resulted in a research complex in West Jefferson, approximately 15 miles west of the King Avenue site. As a result of this research a total of 15 buildings were radiologically contaminated. This includes 9 buildings, or portions thereof, at King Avenue and 6 buildings at the West Jefferson site.

Although the type and extent of contamination varies, contamination at the King Avenue site and a three-building complex at the West Jefferson South site consists mainly of uranium, thorium, and associated daughter products. The West Jefferson North site contains transuranic (TRU), mixed waste products, and activation product contamination.

In 1986, the Battelle Columbus Laboratories Decommissioning Project (BCLDP) was formed to perform decontamination and decommissioning (D&D) activities to restore these facilities, which are all owned by Battelle, without radiological restrictions. As of July 1995, a total of six buildings, three at West Jefferson South and three at King Avenue, have been completed.

The BCLDP consists of three distinct groups integrated into a successful project team. Battelle Columbus Operations provides management support to the project as well as technical, oversight, and regulatory compliance support. APEX Environmental Inc. provides safety, industrial hygiene, and environmental support, and Applied Radiological Control (ARC) provides both health physics and decontamination labor support for the project.

MERCURY CONTAMINATED DRAIN PIPE

Currently, mercury contaminated drain pipe has been identified and remediated in two buildings, KA-3 and KA-4. Various research activities involving enriched uranium, natural uranium, depleted uranium, and beryllium were conducted in KA-3. In addition, a powder metallurgy facility, a melt facility, a metallography facility, and a ceramics research facility were located in KA-3. A radiochemistry laboratory, a metallography laboratory, and an encapsulation facility for highly enriched uranium was located in KA-4.

The mercury contamination most likely resulted from contributing sources. In KA-3, research projects using large amounts of mercury were conducted for many years. Laboratory instruments that contained mercury, including manometers and thermometers, were occasionally broken, leaking their contents onto floor areas. It was common for mercury to enter the drain line system.

The KA-3 drain pipes directly servicing the research processes utilizing large amounts of mercury were severely contaminated. However, visible mercury was also found throughout most other drain lines in KA-3. Drain lines in KA-4 were much less contaminated than those in KA-3. Drain samples revealed small amounts scattered throughout the drain line system. It was impossible to pin point exactly which drain lines were mercury contaminated and which ones were not. Therefore, all drain lines were removed assuming mercury was present. The contaminated drain lines included cast iron as well as vitrified clay. The cast iron drain lines were located in pipe chases and in the overheads. The vitrified clay drain lines were located in the soil under the concrete floor slab.

In addition to safety and health requirements needed for radiological protection, additional safe guards were instituted for the decontamination of mercury contaminated drain lines. Mercury is a poisonous, odorless liquid metal that can enter the body through the lungs, the skin, and the digestive system. Inhalation of mercury vapors is the most common cause of mercury poisoning. Acute poisoning is characterized by chest pains, shortness of breath, inflammation of the mouth and gums, headaches, and fever. More common among the work force is chronic poisoning. Symptoms include inflammation of the mouth and gums, weakness, loss of appetite and weight, central nervous system disorders, and tremors. Personality changes including irritability, temper outbursts, and shyness may also occur. Because mercury is odorless and it vaporizes at 10 degrees Fahrenheit, it is especially dangerous. The Occupational Safety and Health Administration has established a Permissible Exposure Limit (PEL) of 0.1 milligrams per cubic meter of air (mg/m3), which is enforced as an eight hour time weighted average (TWA).

This paper focuses on the methods used to remove the drain pipes, the method used to remove the mercury from the pipes, the safe work practices employed during the tasks, industrial hygiene monitoring results, and the waste disposal methods and cost savings. The work instruction process including the industrial safety checklist will also be addressed.

WORK INSTRUCTIONS

All work conducted at the BCLDP originates with a work instruction which is generated by operations management. The work instruction identifies the scope of work, applicable procedures, safety and health requirements, man power requirements, work schedule, and charge account number. The Safety and Health Department, Waste Management Department, and Health Physics Department reviews the work instruction and adds safety checklists and radiological work permits. This allows for a pro-active approach to successfully completing the task in a safe and cost effective manner.

The work instructions for the drain line removal and honing tasks were detailed and specific. The goals were to remove the pipes without spilling mercury, and to keep employee exposure to a minimum. The work instructions clearly identified the steps in the removal and honing processes and addressed the safety and health concerns. An industrial safety checklist was attached to the work instruction and addressed the following: personal protective equipment (PPE), hazardous materials/chemicals, confined spaces, electrical, fall protection, walking and working surfaces, ladders and scaffolds, hoists, cranes and slings, lift trucks, aerial lifts, hand and power tools, and welding and cutting. Also, special requirements were listed in a general comment section.

Safe Work Plans (SWPs) are developed for work that is determined to be of greater risk to personnel, property, or the environment. Because a detailed and specific work instruction was developed, and only a small amount of mercury was present in the pipes, SWPs were not used for the drain line tasks.

DRAIN PIPE REMOVAL METHOD

The bag enclosure method was the main drain line removal method. A plastic bag was placed around the section of pipe to be removed to avoid spilling the mercury. Slightly different variations were used for the overhead lines and the lines located in the soil. The lines in the overhead areas were cast iron. After the bag was placed around the section of pipe to be removed, a ratchet type hand tool was used to "snap" or "break" the pipe. The loose section was then brought to floor level and then sealed. The remaining open section was also sealed. The process was repeated until all pipe was removed. Scaffolding or ladders was used to access the piping. In case of an incidental release, plastic sheeting (Herculite) was placed on the floor. The floor drains in the immediate area were sealed with tape, and the work area was restricted with barricade tape.

The vitrified clay drain lines, which were located in the basement soil, presented a challenge from the beginning of the task. The lines were located from one to five feet below the concrete floor slab. A concrete cutting subcontractor was hired to cut the concrete floor. BCLDP decontamination technicians removed the cut sections of floor slab with a mechanical lifting device.

The soil was excavated down to the middle of the pipe. The majority of soil was removed by hand shoveling; however, a small backhoe was used in some areas because of the hard, compacted soil type. Extreme caution was exercised to avoid crushing the pipe, which could contaminate soil. Soil surrounding the pipe was excavated by hand using gardening tools.

Plastic sheeting was slipped under the drain pipe to prevent an incidental release into the soil. The sections were easily separated at the joints, and then capped and sealed. The pipes were transferred to another area that was set up specifically for the honing operation. Additional lighting was set up to aid in the detection of mercury in the soil. The majority of piping was in good condition with no leaks. A few leaking sections were identified and a soil clean up plan was developed. The mercury contaminated soil was shoveled into 55-gallon drums and then sampled. A Jerome Mercury Vapor Analyzer, with a cup attachment, was used as a field test to determine if all the mercury was cleaned up. Soil samples were also collected and sent to a laboratory to verify that the clean up was successful.

MERCURY REMOVAL METHOD/WASTE MANAGEMENT

A major cost savings was implemented by the BCLDP by segregating the mercury contamination from the radioactive contaminated drain lines. Nearly 3,000 linear feet of drain lines were decontaminated for mercury. The lead joints were also removed.

Free mercury was segregated and monitored for radioactivity before being released for disposal. The pipes were honed and rinsed with a mercury chelating agent wash and then disposed of as low-level waste (LLW) after passing mercury analysis.

Lead seals were removed from pipe joints by mechanical fracturing and the lead was then segregated for disposal. In some cases, the entire joint had to be disposed of as LLW because of the difficulty to decontaminate the non-linear pipe sections for mercury.

The mixed waste segregation of lead and mercury waste yielded a savings in excess of $400,000. The cost avoidance included the manpower to perform the segregation and the implementation of the most cost effective means of disposal. Because this waste segregation activity is a cost proven effective option, it is now being implemented for other D&D tasks at the BCLDP.

SAFE WORK PRACTICES

General Hazard Communication (Hazcom) training is required for all BCLDP personnel. In addition, specific mercury hazard communication training was required for all personnel involved in the drain line removal and honing task. The OSHA Guideline for Incidental Mercury Releases was the backbone of the Hazcom training.

PPE for drain pipe removal included cloth coveralls, rubber gloves, safety glasses, and face shields. In areas that contained known large quantities of mercury, or when vapors levels dictated so, disposable cloth coveralls and full-face negative pressure respirators with Mersorb cartridges were also required. Only a small portion of the work required respiratory protection.

Additional safe work practices were used for the honing operation, due to the radiological work requirements. Because the honing process was a wet operation, radiological requirements included the use of plastic coveralls and supplied air bubble hoods for respiratory protection. A lab hood was designed to control mercury vapors. The operation was set up directly in front of the lab hood. Also, air conditioning was used to keep the room as cool as possible to avoid excessive vaporization.

Hako Mercury HEPA/charcoal vacuum cleaners were used for incidental releases and for general area clean up. Good housekeeping was essential to keep the vapor concentrations low. Air samples were collected on the perimeter of the work area to ensure that the engineering controls were effective and that support personnel were not being overexposed.

INDUSTRIAL HYGIENE MONITORING AND RESULTS

Mercury vapors were monitored with a Jerome Mercury Vapor Monitor, Jerome Mercury Vapor Dosimeters, and passive dosimeter badges. The Jerome Mercury Vapor Monitor was instrumental in determining the vapor levels as the tasks progressed. Mercury vapor monitoring was conducted daily during all types of tasks associated with the drain pipe removal and honing operations. Monitoring was also conducted during incidental release clean-up. The Jerome Mercury Vapor Monitor was an essential part of the drain pipe D&D task.

The monitor was constantly used to collect "grab" samples during all the drain pipe operations. Because vapor levels were known, a conservative approach in regards to PPE was not warranted, especially regarding respiratory protection. Although OSHA has not established an Action Level

for mercury vapor, the BCLDP Safety Department set a limit at 0.05 mg/m3. If vapor concentrations reached this limit, BCLDP Safety was contacted to further evaluate the situation. Respiratory protection was usually required for work at or above the Action Level.
Personal Breathing Zone (BZ) samples were also collected to evaluate the concentrations based on an 8-hour TWA. Passive dosimeter badges were used initially; however, the turnaround time for laboratory analysis was inconvenient. A Jerome dosimeter kit, used in conjunction with the Jerome Mercury Vapor Monitor, was purchased to eliminate this problem. The dosimeter was connected to a low volume sampling pump and after monitoring was complete, the dosimeter was analyzed by the main unit. BZ sample results are presented in Table 1.

Table 1. Breathing Zone Results

Activity	8-hr TWA, g/m3, Range		
Pipe Honing	none detected	--	9.6
Clean-out of Mercury Vacuum		0.096	
Soil Remediation	0.001	--	0.011
Drain Pipe Removal	none detected	--	0.014

CONCLUSION

The drain pipe removal and honing tasks were completed in a safe, cost effective manner. The detailed work instructions provided an effective plan for the team members to follow. The industrial safety checklist added additional specific health and safety requirements to the work instruction document.

The simple bag removal method provided an excellent means of preventing incidental releases of mercury. It should be noted, however, that pipe openings must be tightly sealed to prevent leakage during transport and storage. Another option is emptying the gross amounts of liquid at the removal site. Mercury vapor concentrations must be carefully monitored if this option is chosen.

The safe work practices set up for the tasks helped ensure a safe operation. The Hazcom training informed all team personnel of hazard associated with working with mercury and the methods that keep mercury exposures as low as possible. The Hako Mercury/HEPA charcoal vacuum cleaners were efficient at cleaning up incidental releases; however, the manufacturers instructions must be carefully followed for the unit to function properly. A core group of personnel were trained on proper maintenance of the units and were assigned the responsibility for maintaining them. Due to the success of this project, the same safe work practices are currently being used for all drain pipe removal tasks. This includes pipes which are contaminated with other constituents as well as mercury.

Mercury vapor concentrations for most activities were relatively low. Elevated vapor concentrations were detected during incidental release clean up, especially if mercury was released from the drain pipes located in the overheads, ten feet above floor level. Vapor concentrations usually remained low during the vitrified clay pipe removal. Because the pipes were already at floor level, mercury was not dispersed into tiny droplets if incidently released. Vapor concentrations during honing operations were usually low, due to the negative ventilation work station that was constructed.

The Jerome Mercury Vapor Monitor also needs routine maintenance to ensure that it is functioning. The small filter in the monitoring tip needs to be changed frequently. The filter absorbs mercury vapors and skews the results. The tubing inside the unit must also be inspected to ensure it is not obstructed. If the tubing is obstructed or crimped, air will not enter the analyzing chamber. The readout on the instrument will show no mercury detected but it could be a false negative result. A functional test kit is available through the company to determine if the instrument is within calibration limits. It is recommended that the unit be inspected on a daily basis and that a functional test be conducted on a monthly basis.

Although the approach BCLDP chose for the mercury contaminated drain pipe removal and honing operation was very basic and simple, great success was achieved at a nominal price. Most of the costs were due to labor. Setting up the honing area was relatively inexpensive. The other tools needed for job were already available on the project, with the exception of the Jerome Mercury Vapor Monitor. The instrument is expensive, (approximately $6,000.00), but it pays for itself in the long run because of the time and money it saves for analytical results.